Animal Thinking

Donald R. Griffin

Ethologists are once again investigating the possibility that animals have conscious awareness

What is it like to be an animal? What do monkeys, dolphins, crows, sunfishes, bees, and ants think about? Or do nonhuman animals experience any thoughts and subjective feelings at all? Aside from Lorenz (1963) and Hediger (1947, 1968, 1980) very few ethologists have discussed animal thoughts and feelings. While seldom denying their existence dogmatically, they emphasize that it is extremely difficult, perhaps impossible, to learn anything at all about the subjective experiences of another species. But the difficulties do not justify a refusal to face up to the issue. As Savory (1959) put the matter, "Of course to interpret the thoughts, or their equivalent, which determine an animal's behaviour is difficult, but this is no reason for not making the attempt to do so. If it were not difficult, there would be very little interest in the study of animal behaviour, and very few books about it" (p. 78).

Most biologists and psychologists tend, explicitly or implicitly, to treat most of the world's animals as mechanisms, complex mechanisms to be sure, but unthinking robots nonetheless. Mechanical devices are usually considered to be incapable of conscious thought or subjective feeling, although it is currently popular to ascribe mental experiences to computer systems. John (in Thatcher and John 1977), among others, has equated consciousness with a sort of internal feedback whereby information about one part of a pattern of information flow acts on another part. This may be a necessary condition for conscious thinking, but it is also an aspect of many physiological processes that operate without any conscious awareness on our part.

Many comparative psychologists seem petrified by the notion of animal consciousness. Historically, the science of psychology has been reacting for fifty years or more against earlier attempts to understand the workings of the human mind by introspective self-examination—trying to learn how we think by thinking about our thoughts. This effort led to confusing and contradictory results, so in frustration experimental psychologists largely abandoned the effort to understand human consciousness, replacing introspection with objective experiments. While experiments have been very helpful in analyzing learning and other human abilities, the rejection of any concern with consciousness and subjective feelings has gone so far that many psychologists virtually deny their existence or at least their accessibility to scientific analysis.

In one rather extreme form of this denial, Harnad (1982) has argued that only after the functioning of our brains has determined what we will do does an illusion of conscious awareness arise, along with the mistaken belief that we have made a choice or had control over our behavior. The psychologists who thus belittle and ignore human consciousness can scarcely be expected to tell us much about subjective thoughts and feelings of animals. If we cannot gather any verifiable data about our own thoughts and feelings, the argument has run, how can we hope to learn anything about those of other species?

A long-overdue corrective reaction to this extreme antimentalism is well under way. To a wide range of scholars, and indeed to virtually the whole world outside of narrow scientific circles, it has always been self-evident that human thoughts and feelings are real and important (see, for example, MacKenzie 1977 and Whiteley 1973). This is not to underestimate the difficulties that arise when one attempts to gather objective evidence about other people's feelings and thoughts, even those one knows best. But it really is absurd to deny the existence and importance of mental experiences just because they are difficult to study.

Why do so many psychologists appear to ignore a central area of their subject matter when most other branches of science refrain from such self-inflicted paralysis? The usual contemporary answer to such a question is that a relatively new sort of cognitive psychology has developed during the past twenty or thirty years, based in large part on the analysis of human and animal behavior in terms of information-processing (reviewed in Norman 1981). Analogies to computer programs play a large part in this approach, and many cognitive psychologists draw their inspiration from the success of computer systems, feeling that certain types of programs can serve as instructive models of human thinking. Words that used to be reserved for conscious human beings are now commonly used to describe the impressive accomplishments of computers. Despite the

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Figure 1. A chimpanzee, having selected a suitably shaped small branch, strips it of twigs and leaves, transforming it into a serviceable tool for capturing termites. The chimpanzee will then walk to a termite nest, often at a considerable distance, and probe it with the stick for termites. Such behavior, which differs radically from other activities of chimpanzees, seems difficult to understand unless the animal is consciously thinking about gathering termites while preparing the probe. (Photograph by Linda Koebner, Bruce Coleman Inc.)

optimism of computer enthusiasts, however, it is highly unlikely that any computer system can spontaneously generate subjective mental experience (Boden 1977; Dreyfus 1979; Baker 1981).

Conspicuously absent from most of contemporary cognitive psychology is any serious attention to conscious thoughts or subjective feelings. For example, Wasserman (1983) defends cognitive psychology to his fellow behaviorists by arguing that it is not subjective and mentalistic. Analyzing people as though they were computers may be useful as an initial, limited approach, just as physiologists began their analysis of the functioning of hearts by drawing analogies to mechanical pumps. But it is important to recognize the limitations inherent in this approach; it suffers from the danger of leading us into what Savory (1959) called by the apt but unfortunately tongue-twisting name of "the synechdochaic fallacy." This means the confusion of a part of something with the whole, or as Savory put it, "the error of nothing but." Information-processing is doubtless a necessary condition for mental experience, but is it sufficient? Human minds do more than process information; they think and feel. We experience beliefs, desires, fears, expectations, and many other subjective mental states.

Many cognitive psychologists imply that a computer system that could process information exactly as the human brain does would duplicate all essential elements of thinking and feeling; others simply feel that subjective experience is beyond the reach of scientific investigation. Perhaps the issue will someday be put to an empirical test, but the extent and the complexity of information-processing in our brains is so great that available procedures can detect only a tiny fraction of it, and even if it could be monitored in full detail, we do not know whether any computer system could duplicate it.

The difference between conscious and nonconscious states is a significant one, yet most scientists concerned with animal behavior have felt that looking for consciousness in animals would be a futile anachronism. This defeatist attitude is based in part on convincing evidence that we do a great deal of problem-solving, decision-making, and other kinds of information-processing without any consciousness of what is going on. Harnad (1982) bases his belief that human consciousness is merely an illusion on the fact that we are conscious of only the tip of the iceberg of information-processing in our brains. Indeed the ratio of conscious to unconscious brain activity is probably even smaller than the density ratio of ice to water. The intellectual excitement of this discovery has obscured the obvious fact that we are conscious some of the time, and we certainly do experience many sorts of thoughts and feelings that are very important to us and our companions. If the choice were open, would anyone prefer a lifelong state of sleepwalking?

What behavior suggests conscious thinking?

Just what is it about some kinds of behavior that leads us to feel that it is accompanied by conscious thinking? Comparative psychologists and biologists worried about this question extensively around the turn of this century. No clear and generally accepted answers emerged from their thoughtful efforts, and this is one reason why the behavioristic movement came to dominate psychology.

Complexity is often taken as evidence that some behavior is guided by conscious thinking. But complexity is a slippery attribute. One might think that simply running away from a frightening stimulus was a rather simple response, yet if we make a detailed description of every muscle contraction during turning and running away, the behavior becomes extremely complex. But, one might object, this complexity involves the physiology of locomotion; what is simple is the direction in which the animal moves. If we then ask what sensory and central nervous mechanisms cause the animal to move in this direction, the matter again becomes complex. Does the animal continuously listen to the danger signal and push more or less hard with its right or left legs in order to keep the signal directly behind it? Or does it head directly toward some landmark? If the latter,

Figure 2. The assassin bug at the top has camouflaged itself chemically and tactilely by gluing bits of a termite nest all over its body. In this way it is able to capture a termite at the opening of the nest without alarming the soldier termites. After sucking out the termite's semifluid organs, the assassin bug jiggles the empty exoskeleton in front of the nest opening in order to attract another termite worker, which will normally attempt to consume or dispose of the corpse. When a second termite worker seizes the first, it is then captured and consumed itself, as shown in the photograph below, and the process may be repeated continuously many times by the same assassin bug. The extraordinary complexity and coordination of these actions strongly suggest conscious thought, even though the assassin bug's central nervous system is very small. (Photographs by Raymond A. Mendez.)

how does it coordinate vision and locomotion? Again one might say that the direction of motion is simple, and it is irrelevant to worry about the complexities of the physiological mechanisms involved.

But how is this simple direction "away from the danger" represented within the animal's central nervous system? Does the animal employ the concepts of *away from* and *danger*? If so, how are such concepts established? Even though we cannot answer the question in neurophysiological terms, it is clear that running away from something is a far simpler behavior than, say, the construction of a bird's nest. Conversely, even the locomotor motions of a caterpillar that will move toward a light with a machine-like consistency hour after hour are not simple when examined in detail. What is simple is the abstract notion of *toward* or *away*, but the mechanistic interpretation of animal behavior tends to deny that the animal could think in terms of even such a simple abstraction.

One very important attribute of animal behavior that seems intuitively to suggest conscious thinking is its adaptability to changing circumstances. If an animal repeats some action in the same way regardless of the results, we assume that a rigid physiological mechanism is at work, especially if the behavior is ineffective or harmful to the animal. When a moth flies again and again at a bright light or burns itself in an open flame, it is difficult to imagine that the moth is thinking, although one can suppose that it is acting on some thoughtful but misguided scheme. When members of our own species do things that are self-damaging or even suicidal, we do not conclude that their behavior is the result of a mechanical reflex. But to explain the moth flying into the flame as thoughtful but misguided seems far less plausible than the usual interpretation that such insects automatically fly toward a bright light, which leads them to their death in the special situation where the brightest light is an open flame.

Conversely, if an animal manages to obtain food by a complex series of actions that it has never performed before, intentional thinking seems more plausible than rigid automatism. For example, Japanese macaques learned a new way to separate grain from inedible material by throwing the mixture into the water; the kernels of grain would float while the inorganic sand and other particles tended to sink (Kawai 1965). These new types of food handling were first devised by a few monkeys, then were gradually acquired by other members of their social group through observational learning.

Behavioral versatility came into play in a spectacular fashion in the 1930s when two species of tits discovered that milk bottles delivered to British doorsteps could be a source of food (Fisher and Hinde 1949; Hinde and Fisher 1951). At that time milk-bottle tops were made of soft metal foil, and the milk was not homogenized, so the cream rose to the top of the bottle. One or more birds discovered that the same type of behavior used to get at insects hidden under tree bark could also be used to get cream from milk bottles. The people whose milk was disturbed immediately noticed it, and careful studies were made of the gradual spread of this behavior throughout much of England. A change in the technology of covering milk bottles eventually ended the whole business, but meanwhile thousands of birds had learned, almost certainly through observation, to exploit a newly available food source.

Connected patterns of behavior

Another criterion upon which we tend to rely in inferring conscious thinking is the element of interactive steps in a relatively long sequence of appropriate behavior patterns. Effective and versatile behavior often entails many steps, each one modified according to the results of the previous actions. In such a complex se-

quence the animal must pay attention not only to the immediate stimuli, but also to information obtained in the past. Psychologists once postulated that complex behavior can be understood as a chain of rigid reflexes, the outcome of one serving as stimulus for the next. Students of insect behavior have generally accepted this explanation for such complex activities as the construction of elaborate shelters or prey-catching devices, ranging from the underwater nets spun by certain caddis-fly larvae to the magnificent webs of spiders. But the steps an animal takes often vary, depending on the results of the previous behavior and on many influences from the near or distant past. The choice of *which* past events to attend to may be facilitated by conscious selection from a broad spectrum of memories.

Figure 3. With an apparent deliberateness that suggests intentional thinking, nesting killdeer will conspicuously lead a potential predator away from their nest or young, adjusting the speed of their abnormally awkward movements away from the nest so as to remain within sight but out of reach of the intruder. Quite often the killdeer acts as if it is injured, as shown here, a behavior that would make it more attractive to a predator. The killdeer will sometimes employ a very different tactic in response to approaching cattle, which may trample on eggs or nestlings but will not eat them; the birds will then stand close to the nest and spread their wings in a conspicuous display that usually causes the cattle to step aside. (Photograph by Noble S. Proctor.)

An outstanding example of such sequences of interactive behaviors is the use of probes by chimpanzees to gather termites from their mounds (Goodall 1968, 1971). The chimpanzee prepares a probe by selecting a suitable branch, pulling off its leaves and side branches, breaking the stick to the right length, carrying it—often for several minutes—to a termite mound, and then probing into the openings used by the termites (see Fig. 1). If the hole yields nothing, the chimpanzee moves to another one. Even after the tool has been prepared, its use is far from stereotyped. When curious scientists try to imitate the chimpanzees' techniques, they find it rather difficult and seldom gather as many termites. It is especially interesting that the young chimpanzees seem to learn this use of tools by watching their mothers or other members of their social group. Youngsters have been observed making crude and relatively ineffectual attempts to prepare and use their own termite probes; the termite "fishing" of chimpanzees gives every evidence of being learned.

Examples can be found among insects of long, complex sequences of behaviors that are as suggestive of thought as the chimpanzee's use of a termite probe. McMahan (1982) has discovered that in tropical rain forests one species of assassin bug, a predatory insect, uses two effective tricks, illustrated in Figure 2, to capture the workers of termite colonies. The bug glues small bits of the outer layers of a termite nest to its head, back, and sides. Then it stands near an opening to the termite colony. The bits of termite nest on the assassin bug apparently smell and perhaps feel familiar to the termites, so no alarm signals are emitted, which otherwise would attract the well-armed members of the soldier caste that attack intruders. Although the assassin bug's actions often attract soldier termites, its camouflage seems to prevent them from recognizing it as an intruder, and they return to the nest. This chemical and tactile camouflage allows the assassin bug to reach into the opening and capture a termite worker, which it kills and consumes by sucking out all the semifluid internal organs, leaving only the exoskeleton.

Such camouflage-assisted prey capture is remarkable enough, but the next step is even more thought-provoking. The assassin bug pushes the empty exoskeleton of its victim into the nest opening and jiggles it gently. Another termite worker seizes the corpse as part of a normal behavior pattern of devouring the body of a dead sibling or carrying the corpse away for disposal. The assassin bug pulls the exoskeleton of the first victim out with the second worker attached. This one is eaten and its empty exoskeleton used in another "fishing" effort. In one case an assassin bug was observed to thus devour thirty-one termites before moving away with a fully distended abdomen.

When chimpanzees fashion sticks to probe for termites, their actions are considered among the most convincing cases of intentional behavior yet described for nonhuman animals. When McMahan discovers assassin bugs carrying out an almost equally elaborate feeding behavior, must we assume that the insect is only a genetically programmed robot incapable of understanding what it does? Perhaps we should be ready to infer conscious thinking whenever any animal shows such ingenious behavior, regardless of its taxonomic group and our preconceived notions about limitations of animal consciousness.

An example even more suggestive of thoughtful behavior among insects is the so-called "dance language" of honeybees, which was discovered by the remarkably brilliant and original experiments of von Frisch (reviewed by von Frisch 1967, 1972). One significant reaction to von Frisch's discovery was that of Jung (1973). Late in his life he wrote that although he had believed insects were merely reflex automata:

> this view has recently been challenged by the researches of Karl von Frisch. . . . Bees not only tell their comrades, by means of a peculiar sort of dance, that they have found a feeding-place, but they also indicate its direction and distance, thus enabling beginners to fly to it directly. This kind of message is no different in principle from information conveyed by a human being. In the latter case we would certainly regard such behavior as a conscious and intentional act and can hardly imagine how anyone could prove in a court of law that it had taken place unconsciously. . . . We are . . . faced with the fact that the ganglionic system apparently achieves exactly the same result as our cerebral cortex. Nor is there any proof that bees are unconscious.

In many cases the networks of informative events that suggest animal thinking are sufficiently complicated that we are not sure what the animal is doing even when we know most of the relevant facts. Consider, for example, how certain ground-nesting birds, such as the killdeer or piping plovers, lead predators away from their nests or young. At a considerable distance, long before an approaching large intruder, such as a person or other mammal, can see the cryptically colored bird or its eggs, the plover may stand up and walk slowly to a point a few meters from the nest. Then the bird may flutter slowly but conspicuously away from the nest, staying relatively close to the intruder. It almost always makes loud piping or peeping sounds similar to those a bird makes when disturbed or mildly irritated.

It is common for the bird to hold its tail or wing in an abnormal position as it moves. Often the tail almost drags on the ground, and the wings are slightly extended, sometimes one more than the other, strongly suggesting some weakness or injury. After running a few meters, the bird may flop about on the ground, extending one or both wings, as if injured. This behavior, shown in Figure 3, is often called the "broken-wing display," and it requires considerable effort for an observer to believe that the bird is really quite healthy. Predators are extremely sensitive to minor differences in the gait and demeanor of potential prey and are much more likely to attack animals that are behaving abnormally.

Throughout most of this predator-distraction behavior, the bird watches the intruder. Typically it does not move in a straight line and stops from time to time. If the intruder approaches, the bird moves farther ahead. If not, the bird usually flies back closer to the intruder and repeats the behavior. The bird will allow the intruder to approach quite close, sometimes within two meters, but it always moves just fast enough and far enough to avoid capture. Typically the bird continues the injury simulation while leading the intruder some distance away from the nest or young. Finally, however, it flies away rapidly, usually in the same direction, then circling back to the general vicinity, though seldom to the exact spot, where the eggs or young are located. One Wilson's plover, a close relative of the killdeer and piping plover, led me more than 300 meters along a sandy beach before flying off.

Killdeer have been observed to use very different tactics when their nests are approached by cattle, which may trample on eggs or nestlings but will not eat them. Rather than moving away from the nest and fluttering as though injured, the birds stand close to the nest and spread their wings in a conspicuous display that usually causes the cattle to step aside (Skutch 1976).

Adaptations to novelty

One further consideration can help refine the criteria for determining the presence of conscious thought. We can easily change back and forth between thinking consciously about our own behavior and not doing so. When we are learning some new task such as swimming, riding a bicycle, driving an automobile, flying an airplane, operating a vacuum cleaner, caring for our teeth by some new technique recommended by a dentist, or any of the large number of actions we did not formerly know how to do, we think about it in considerable detail. But once the behavior is thoroughly mastered, we give no conscious thought to the details that once required close attention.

This change can also be reversed, as when we make the effort to think consciously about some commonplace and customary activity we have been carrying out for some time. For example, suppose you are asked about the pattern of your breathing, to which you normally give no thought whatsoever. But you can easily take the trouble to keep track of how often you inhale and exhale, how deeply, and what other activities accompany different patterns of breathing. You can find out that it is extremely difficult to speak while inhaling, so talking continuously requires rapid inhalation and slower exhalation. This and other examples that will readily come to mind if one asks the appropriate questions show that we can bring into conscious focus activities that usually go on quite unconsciously.

The fact that our own consciousness can be turned on and off with respect to particular activities tells us that in at least one species it is not true that certain behavior patterns are always carried out consciously while others never are. It is reasonable to guess that this is true also for other species. Well-learned behavior patterns may not require the same degree of conscious attention as those the animal is learning how to perform. This in turn means that conscious awareness is more likely when the activity is novel and challenging; striking and unexpected events are more likely to produce conscious awareness.

Thus it seems likely that a widely applicable, if not all-inclusive, criterion of conscious awareness in animals is *versatile adaptability of behavior to changing circumstances and challenges.* If the animal does much the same things regardless of the state of its environment or the behavior of other animals nearby, we are less inclined to judge that it is thinking about its circumstances or what it is doing. Consciously motivated behavior is more plausibly inferred when an animal behaves appropriately in a novel and perhaps surprising situation that requires specific actions not called for under ordinary circumstances. This is a special case of versatility, of course, but the rarity of the challenge combined with the appropriateness and effectiveness of the response are important indicators of thoughtful actions.

For example, Janes (1976) observed nesting ravens make an enterprising use of rocks. He had been closely observing ten raven nests in Oregon, eight of which were near the top of rocky cliffs. At one of these nests two ravens flew in and out of a vertical crack that extended from top to bottom of a twenty-meter cliff. Janes and a companion climbed up the crevice and inspected the six nearly fledged nestlings. As they started down,

Figure 4. When sea otters cannot open shellfish with their claws or teeth, they often employ a stone for the purpose, smashing it against the shells. The apparently conscious, intentional nature of the behavior is further indicated by the fact that an otter carefully selects a stone of suitable size and weight and often carries the stone under its armpit for considerable periods. (Photograph by William F. Bryan.)

both parents flew at them repeatedly, calling loudly, then landed at the top of the cliff, still calling. One of the ravens then picked up small rocks in its bill and dropped them at the human intruders. Several of the rocks showed markings where they had been partly buried in the soil, so the birds presumably had pried them loose. Only seven rocks were dropped, but the raven seemed to be seeking other loose ones and apparently stopped only because no more suitable rocks were available.

While many birds make vigorous efforts to defend their nests and young from intruders, often flying at people who come too close, regurgitating or defecating on them, and occasionally striking them with their bills, rock throwing is most unusual. Nor do ravens pry out rocks and drop them in other situations. It is difficult to avoid the inference that this quite intelligent and adaptable bird was anxious to chase the human intruders away from its nest and decided that dropping rocks might be effective.

There are limits to the amount of novelty with which a species can cope successfully, and this range of versatility is one of the most significant measures of mental adaptability. This discussion of adaptable versatility as a criterion of consciousness implies that conscious thinking occurs only during learned behavior, but we should be cautious in accepting this belief as a rigid doctrine.

Another aspect of conscious thinking is anticipation and intentional planning of an action with conscious awareness of its likely results. An impressive example is the use of small stones by sea otters to detach and open shellfish (Kenyon 1969). These intelligent aquatic carnivores feed mostly on sea urchins and mollusks. The sea otter must dive to the bottom and pry the mollusk loose with claws or teeth, but some shells, especially abalones, are tightly attached to the rocks and have shells that are too tough to be loosened in this fashion. The otter will search for a suitable stone, which it carries while diving, then uses the stone to hammer the shellfish loose, holding its breath all the while.

The otter usually eats while floating on its back, as shown in Figure 4. If it cannot get at the fleshy animal inside the shell, it will hold the shell against its chest with one paw and pound it with the stone. The otter often tucks a good stone under an armpit as it swims or dives. Although otters do not alter the shapes of the stones, they do select ones of suitable size and weight and often keep them for considerable periods. The otters use tools only in areas where sufficient food cannot be obtained by other methods. In some areas only the young and very old sea otters use stones; vigorous adults can dislodge the shellfish with their unaided claws or teeth. Thus it is far from a simple stereotyped behavior pattern, but one that is used only when it is helpful. Sea

otters sometimes use floating beer bottles to hammer open shells. Since the bottles float, they need not be stored under the otter's armpit.

Anticipation and planning are of course impossible to observe directly in another person or animal, but indications of their likelihood are often observable. As early as the 1930s Lorenz studied the intention movements of birds (Lorenz 1971), and other ethologists have noted that these movements, small-scale preliminaries to major actions such as flying, often serve as signals to others of the same species. Although Lorenz interpreted the movements as indications that the bird was planning and preparing to fly, the term *intention movement* has been quietly dropped from ethology in recent years. I suspect this is because the behavioristic ethologists fear that the term has mentalistic implications. Earlier ethologists such as Daanje (1951) described a wide variety of intention movements in many kinds of animals, but their interest was in whether the movements had gradually become specialized communication signals in the course of behavioral evolution. The possibility that intention movements indicate the animal's conscious intention has been totally neglected by ethologists during their behavioristic phase, but we may hope that the revival of scientific interest in animal thinking will lead cognitive ethologists to study whether such movements are accompanied by conscious intentions.

Animal communication

The very fact that intention movements so often evolve into communicative signals may reflect a close linkage between thinking and the intentional communication of thoughts from one conscious animal to another. These considerations lead us directly to a recognition that because communicative behavior, especially among social animals, often seems to convey thoughts and feelings from one animal to another, it can tell us something about animal thinking: it can be an important "window" on the minds of animals.

Human communication is hardly limited to formal language; nonverbal communication of mood or intentions also plays a large and increasingly recognized role in human affairs. We make inferences about people's feelings and thoughts, especially those of very young children, from many kinds of communication, verbal and nonverbal; we should similarly use all available evidence in exploring the possibility of thoughts or feelings in other species. When animals live in a group and depend on each other for food, shelter, warning of dangers, or help in raising the young, they need to be able to judge correctly the moods and intentions of their companions. This extends to animals of other species as well, especially predators or prey. It is important for the animal to know whether a predator is likely to attack or whether the prey is so alert and likely to escape that a chase is not worth the effort. Communication may either inform or misinform, but in either case it can reveal something about the conscious thinking of the communicator.

Vervet monkeys, for example, have at least three different categories of alarm calls, which were described by Struhsaker (1967) after extensive periods of observation. He found that when a leopard or other large carnivorous mammal approached, the monkeys gave one type of alarm call; quite a different call was used at the sight of a martial eagle, one of the few flying predators that captures vervet monkeys. A third type of alarm call was given when a large snake approached the group. This degree of differentiation of alarm calls is not unique, although it has been described in only a few kinds of animals. For example, ground squirrels of western North America use different types of calls when frightened by a ground predator or by a predatory bird such as a hawk (Owings and Leger 1980).

The question is whether the vervet monkey's three types of alarm calls convey to other monkeys information about the type of predator. Such information is important because the animal's defensive tactics are different in the three cases. When a leopard or other large carnivore approaches, the monkeys climb into trees. But leopards are good climbers, so the monkeys can escape them only by climbing out onto the smallest branches, which are too weak to support a leopard. When the monkeys see a martial eagle, they move into thick vegetation close to a tree trunk or at ground level. Thus the tactics that help them escape from a leopard make them highly vulnerable to a martial eagle, and vice versa. In response to the threat of a large snake they stand on their hind legs and look around to locate the snake, then simply move away from it, either along the ground or by climbing into a tree.

To answer this question, Seyfarth, Cheney, and Marler (1980a, b) conducted some carefully controlled playback experiments under natural conditions in East Africa. From a concealed loudspeaker, they played tape recordings of vervet alarm calls and found that the playbacks of the three calls did indeed elicit the appropriate responses. The monkeys responded to the leopard alarm call by climbing into the nearest tree; the martial eagle alarm caused them to dive into thick vegetation; and the python alarm produced the typical behavior of standing on the hind legs and looking all around for the nonexistent snake.

Inclusive behaviorists—that is, psychologists interested only in contingencies of reinforcement during an individual's lifetime, and ethologists or behavioral ecologists solely concerned with the effects of natural selection on behavior—insist on limiting themselves to stating that an animal benefits from accurate information about what the other animal will probably do. But within a mutually interdependent social group, an individual can often anticipate a companion's behavior most easily by empathic appreciation of his mental state. The inclusive behaviorists will object that all we need postulate is behavior appropriately matched to the probabilities of the companions *behaving* in this way or that—all based on contingencies of reinforcement learned from previous situations or transmitted genetically.

But empathy may well be a more efficient way to gauge a companion's disposition than elaborate formulas describing the contingencies of reinforcement. All the animal may need to know is that another is aggressive, affectionate, desirous of companionship, or in some other common emotional state. Judging that he is aggressive may suffice to predict, economically and parsimoniously, a wide range of behavior patterns depending on the circumstances. Neo-Skinnerian inclusive behaviorists may be correct in saying that this empathy

came about by learning, for example, the signals that mean a companion is aggressive. But our focus is on the animal's possible thoughts and feelings, and for this purpose the immediate situation is just as important as the history of its origin.

Humphrey (1976) has extended an earlier suggestion by Jolly (1966) that consciousness arose in primate evolution when societies developed to the stage where it became crucially important for each member of the group to understand the feelings, intentions, and thoughts of others. When animals live in complex social groupings, where each one is crucially dependent on cooperative interactions with the others, they need to be "natural psychologists," as Humphrey puts it. They need to have internal models of the behavior of their companions, to feel with them, and thus to think consciously about what the other one must be thinking or feeling.

Following this line of thought, we might distinguish between the animals' interactions with some feature of the physical environment or with plants, and their interactions with other reacting animals, usually their own species, but also predators and prey. Although Humphrey has so far restricted his criterion of consciousness to our own ancestors within the past few million years, it could apply with equal or even greater force to other animals that live in mutually interdependent social groups.

All this adds up to the simple idea that when animals communicate to one another they may be conveying something about their thoughts or feelings. If so, eavesdropping on the communicative signals they exchange may provide us with a practicable source of data about their mental experiences. When animals devote elaborate and specifically adjusted activities to communication, each animal responding to messages from its companion, it seems rather likely that both sender and receiver are consciously aware of the content of these messages.

The adaptive economy of conscious thinking

The natural world often presents animals with complex challenges best met by behavior that can be rapidly adapted to changing circumstances. Environmental conditions vary so much that for an animal's brain to have programmed specifications for optimal behavior in all situations would require an impossibly lengthy instruction book. Whether such instructions stem from the animal's DNA or from learning and environmental influences within its own lifetime, providing for all likely contingencies would require a wasteful volume of specific directions. Concepts and generalizations, on the other hand, are compact and efficient. An instructive analogy is provided by the hundreds of pages of official rules for a familiar game such as baseball. Once the general principles of the game are understood, however, quite simple thinking suffices to tell even a small boy approximately what each player should do in most game situations.

Of course, simply thinking about various alternative actions is not enough; successful coping with the challenges of life requires that thinking be relatively rapid and that it lead both to reasonably accurate decisions and to their effective execution. Thinking may be economical without being easy or simple, but consideration of the likely results of doing this or that is far more efficient than blindly trying every alternative. If an animal thinks about what it might do, even in very simple terms, it can choose the actions that promise to have desirable consequences. If it can anticipate probable events, even if only a little way into the future, it can avoid wasted effort. More important still is being able to avoid dangerous mistakes. To paraphrase Popper (1972), a foolish impulse can die in the animal's mind rather than lead it to needless suicide.

I have suggested that conscious thinking is economical, but many contemporary scientists counter that the problems mentioned above can be solved equally well by unconscious information-processing. It is quite true that skilled motor behavior often involves complex, rapid, and efficient reactions. Walking over rough ground or through thick vegetation entails numerous adjustments of the balanced contraction and relaxation of several sets of opposed muscles. Our brains and spinal cords modulate the action of our muscles according to whether the ground is high or low or whether the vegetation resists bending as we clamber over it. Little, if any, of this process involves conscious thought, and yet it is far more complex than a direct reaction to any single stimulus.

We perform innumerable complex actions rapidly, skillfully, and efficiently without conscious thought. From this evidence many have argued that an animal does not need to think consciously to weigh the costs and benefits of various activities. Yet when we acquire a new skill, we have to pay careful conscious attention to details not yet mastered. Insofar as this analogy to our own situation is valid, it seems plausible that when an animal faces new and difficult challenges, and when the stakes are high—often literally a matter of life and death—conscious evaluation may have real advantages.

Inclusive behaviorists often find it more plausible to suppose that an animal's behavior is more efficient if it is automatic and uncomplicated by conscious thinking. It has been argued that the vacillation and uncertainty involved in conscious comparison of alternatives would slow an animal's reactions in a maladaptive fashion. But when the spectrum of possible challenges is broad, with a large number of environmental or social factors to be considered, conscious mental imagery, explicit anticipation of likely outcomes, and simple thoughts about them are likely to achieve better results than thoughtless reaction. Of course, this is one of the many areas where we have no certain guides on which to rely. And yet, as a working hypothesis, it is attractive to suppose that if an animal can consciously anticipate and choose the most promising of various alternatives, it is likely to succeed more often than an animal that cannot or does not think about what it is doing.

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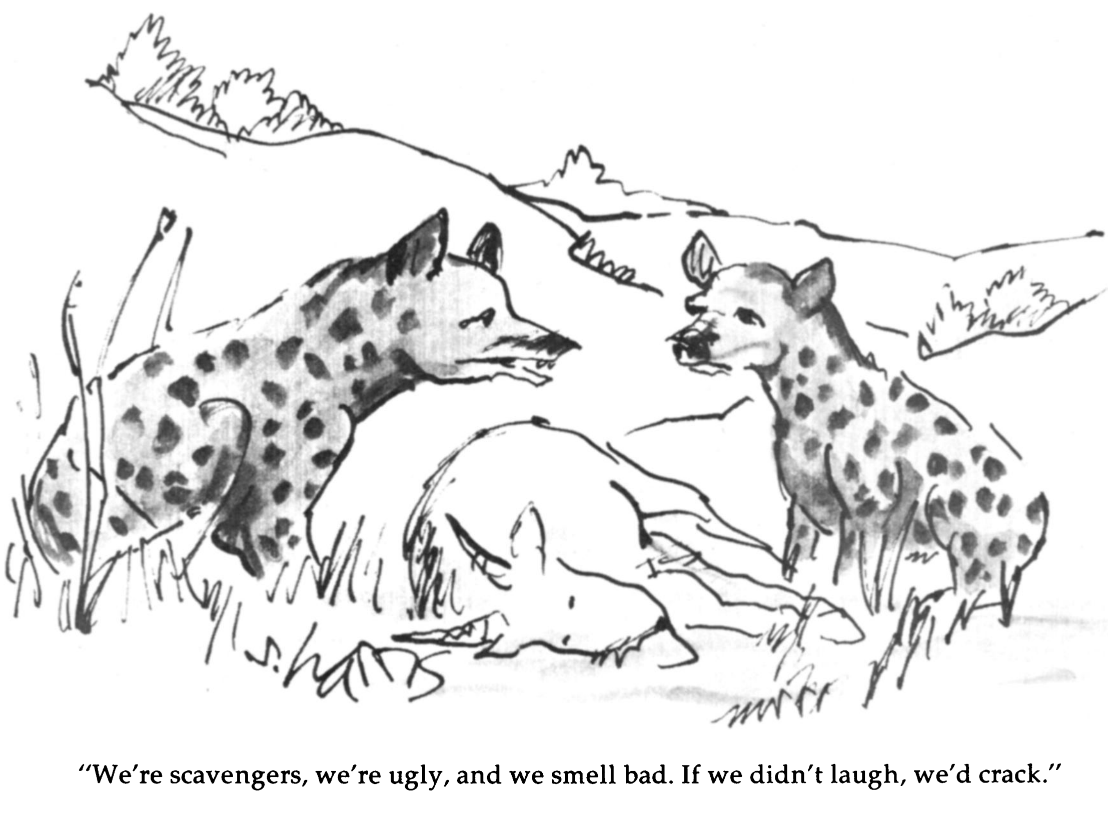

"We're scavengers, we're ugly, and we smell bad. If we didn't laugh, we'd crack."